9. Experiments on Captive Kestrels (*Cerchneis rupicoloides* and *C. naumanni*). (G. A. K. M.)

1899. *Salisbury, Mashonaland.*

January 2. Offered a young kestrel (*Cerchneis rupicoloides*) an *Acræa caldarena;* he took it in his beak, held it for a few seconds and then threw it away with a sharp shake of the head. Then gave him a *Byblia ilithyia*, which he accepted, but after making one or two pecks at it let it drop and would not touch it when it was again offered. I then tried him with an example of *A. nohara-halali* and *A. doubledayi-axina*, but he would have nothing to do with them.

„ 7. Gave the kestrel a large Buprestid beetle (*Psiloptera valens*, Pér. *i.l.*); he seized it in his beak with a cry of evident pleasure, then holding it in his foot tried to eat it, but after a peck or two it slipped from his grasp; I gave it back to him several times, but always with the same result—the beetle was too slippery. *Psiloptera* are all eaten readily by baboons, and it would appear from this that their hard, shiny integuments combined with their torpedo-like shape form a very efficient protection (apart from their procryptic colouring) from all birds which are not sufficiently large to swallow them entire.

„ 8. Offered kestrel two *Blepisanis haroldi*, a small Longicorn with Lycoid markings, but he would not touch them; then a *Lycus rostratus*, at which he pecked but was evidently displeased with the taste, and neglected it.

„ 12. Gave kestrel a *Precis pelasgis*, *Junonia cebrene*, *Precis sesamus* ⊕ and *Atella phalantha*. He ate them all with evident relish, though he seemed to experience a little difficulty in managing them at first, as he could not get a good hold with his claw in order to pull them to pieces. So

the first two were practically swallowed whole, but the others were eaten piecemeal. I then offered a larva of *Limnas chrysippus*, which he accepted and held for some moments in his claw as though in doubt, but finally let it drop after a half-hearted peck. On re-presentation he would not touch it, so in order to restore confidence I gave him a grasshopper, on which insects he is usually fed. The species offered happened to have some rather light-green, yellow, and black markings; he took it with evident distrust and soon dropped it, although it was a species he had often eaten before. Thinking that the refusal was due to his experience with the brightly-marked larva of *L. chrysippus*, I offered some dully-coloured green and brown grasshoppers, which were readily eaten, and after them he also ate the one previously refused. I then offered a larva of *Acræa rahira;* he evinced a decided interest in it, but, although it crawled about over his feet, absolutely refused to touch it. This however may have been due to a generalized impression that all caterpillars were distasteful.

January 13. *Cerchneis rupicoloides* ate one *Catopsilia florella*. A young bird of another species (*C. naumanni*) accepted a dead *Papilio demodocus;* for a few moments he seemed undecided where to attack it: then noticing the eye-spots in the hind-wing he promptly pecked them out, afterwards eating the rest.

„ 16. *C. naumanni* ate three *Terias brigitta;* both this species and *C. rupicoloides* refused the Lycoid *Prionocerus dimidiatus* with unmistakable signs of dislike.

„ 21. *C. naumanni* ate one *Precis pelasgis*, one *Axiocerces harpax*, one *Terias brigitta*, one *Catopsilia florella*, and one *Precis sesamus* (*natalensis* form) ⊕, all with

evident appreciation. *C. rupicoloides* appeared to have become tired of butterflies, refusing all, even those it ate before. Swynnerton found that it continually refused the brightly-coloured grasshopper mentioned above, but always ate it with relish when it had been dipped in meal to obscure its colours. *C. naumanni* on the other hand never refused the insect.

January 22. *C. naumanni* accepted a *Papilio corinneus*, but seemed in some doubt as to its edibility; he finally ate the thorax and threw away the abdomen. *Acræa halali* was then offered, tasted, and rejected. *Acræa anemosa* and *Limnas chrysippus* were likewise refused, and shortly afterwards one *Byblia ilithyia* and one *Terias brigitta* were eaten.

„ 23. *C. rupicoloides* escaped, and all the following notes refer only to *C. naumanni*. Kestrel ate one *Dichtha inflata* and one *Amblysterna vittipennis*. A *Lagria*, sp., was tasted and rejected.

„ 25. When very hungry the bird ate part of an *Acræa caldarena*, throwing away the rest. Subsequently he ate four *Belenois severina*, one *Junonia cebrene*, and one *Precis sesamus* (*natalensis* form).

„ 28. Two *Byblia ilithyia* eaten by kestrel. A *Clythra wahlbergi*, with strong Coccinellid odour, was eaten by the kestrel after some hesitation. Kestrel refused the Coccinellid *Epilachna dregei*.

„ 29. A Longicorn (*Ceroplesis fallax*, Pér.) offered to kestrel, which had been kept without food for some time. He was evidently nervous and much impressed by the stridulation of the insect. I therefore pulled the head off the beetle, and the hawk then ate it, but very slowly and in such a way as to lead me to suppose that it was not altogether palatable. Gave a *Piezia sclousi*, head first, to kestrel, which ate it readily though evidently noticing

the acidity of the abdomen. A *Polyhirma ænigma* was at once eaten by kestrel. I then offered him *Graphipterus lineolatus*, tail first; he pecked at it and received a small discharge of acid in the mouth, whereupon he shook his head and began wiping his beak vigorously on the perch, as though to get rid of the taste. Upon the beetle being presented head first, he took it with caution and ate it. The same results were obtained with *Graphipterus wahlbergi*, *G. bilineatus*, and *G. lineolatus*, they being refused when presented tail first and eaten when reversed. It should be noted that these beetles all discharge their secretions violently when captured, and therefore the kestrel would probably receive a comparatively small dose of the acid.

February 1. Gave kestrel an *Atella phalantha;* he seemed a good deal doubtful about it at first, but finally ate it without any signs of distaste. He then ate a *Junonia cebrene* and a *Byblia ilithyia* with manifest enjoyment. I then offered *L. chrysippus;* he accepted it readily, pulled off the head which he discarded, pecked a little at the tough thorax and wings, and then let it drop; on offering it again he took it, gave it a few pecks and jerked it away with his beak. He then ate a *Hamanumida dædalus* and accepted an *A. caldarena*, of which he ate a small part of the abdomen and threw away the rest. After this he ate with pleasure a *P. sesamus* (*natalensis* form), *J. cebrene*, and *B. ilithyia*. Several *Onitis alexis* were then given to the kestrel, which ate them readily. *Anomalipus plebeius* was too hard for him, and after five minutes' hard pecking he had only succeeded in pulling off the head; I therefore broke it up for him, and it was promptly eaten. He then refused *Clinteria infuscata*, *Mylabris holo-*

sericea, *Clerus* sp. (entirely scarlet, with strong verbena-like smell), and *Prionocerus dimidiatus*.

February 3. Kestrel ate several dull-coloured *Curculionidæ* (*Oosomus*, sp., and *Eremnus*, spp.), refusing several *Onthophagus gazella* which were offered, also *Lycus ampliatus*, *L. rostratus*, and *L. constrictus*, all of which were tasted and were very evidently unpleasant.

„ 6. Kestrel refused *Zonitis*, sp., *Eletica rufa*, *Mylabris palliata*, and *Diacantha conifera*, after tasting each.

„ 15. The kestrel had been starved for twenty-four hours, and was very hungry. He ate the following insects, in the order given, with great avidity: two *Teracolus achine*, one *B. ilithyia*, two *Atella phalantha*, one *Junonia cebrene*, and one *Papilio corinneus*. I then gave him an *Acræa caldarena*, of which he first ate the head and swallowed the rest whole, one *A. rahira* was also swallowed whole; *L. chrysippus* was then offered; the bird ate the head, which seemed to raise suspicions in his mind, for he sat considering for some moments, and then began pecking at the thorax and wings and finally dropped it; on re-presentation he seized the butterfly, gave a few pecks at it, and jerked it away. Then one *Acræa axina* and two *A. halali* were swallowed whole, but *A. caldarena* which followed was only partially eaten, fully half being discarded. Another *L. chrysippus* was offered, and the entire head and thorax was eaten before it was thrown down. Later, the bird swallowed whole another *A. rahira* subsequent to eating several grasshoppers.

„ 28. Gave kestrel a *B. ilithyia*, which was eaten rapidly, and a second as well. He then ate a *Precis pelasgis* and another *ilithyia*, but an *Acræa halali* was pecked at once or twice and thrown away, and a fourth

ilithyia was treated in the same way, being apparently mistaken for an *Acræa*. I then offered a female *Anoplocnemis curvipes;* the bird ate the head, but evidently in some doubt; it continued with the thorax however, but showed its dislike by repeated sharp shaking of the head, and finally dropped the abdomen. I put a male of the same bug on its perch, but though it examined it carefully it would not touch it; yet this species is eaten greedily by the baboons.

[There are several very significant results from the above-recorded experiments on kestrels. The rejection of *Byblia*, after trial and rejection of an *Acræa*, may have been due to the superficial resemblance. On the other hand, this bird (*C. rupicoloides*) was apparently not fond of butterflies, for after eating (Jan. 12) *Precis, Junonia*, and *Atella* and (Jan. 13) *Catopsilia*, he refused all Rhopalocera. The refusal of an Acridian marked with bright green, yellow, and black, and its acceptance when the colours were hidden was almost certainly the result of unpleasant experiences with conspicuously-marked insects, of which a particular instance was afforded when the larva of *L. chrysippus* was offered. Such association of impressions brought about by very imperfect resemblances are of great importance in helping us to understand the origin of mimicry, both Batesian and Müllerian, in slight accidental resemblances of a very rough and imperfect kind. It also warns us not to regard as far-fetched or absurd those imperfect likenesses which may well be the early stages of incipient mimicry. The refusal of the Lycoid Longicorn *Blepisanis* may be similarly due to a previous experience of *Lycidæ*, or it may be truly distasteful and synaposematic. The latter interpretation is certainly true of the Lycoid Melyrid *Prionocerus* also refused by the kestrel "with unmistakable signs of dislike."

The other species of kestrel, *C. naumanni*, was much fonder of butterflies and of insects generally, eating the brightly-coloured grasshopper on all occasions. The fact that it took special notice of and pecked at the eye-spots on the hind-wing of *P. demodocus* is of much interest, and recalls an observation of my own quoted on pp. 440, 441. Such observations strongly confirm the interpretation of

eye-spots, especially upon the under-side of the wings, as directive marks leading an enemy to attack a non-vital part, and they tend to refute Portschinski's explanation of them as the representation in colour of drops of some specially-protective fluid (see p. 398).

Butterflies of different groups, *Hesperidæ*, *Pierinæ*, *Nymphalinæ*, were freely eaten, but the rejection of the abdomen of *Papilio corinnæus* by the captive bird which afterwards ate *Byblia* and *Terias*, can only be explained on the supposition of unpalatability, and the same was evidently true in a more marked degree of Acræas and *L. chrysippus*, although parts of these would sometimes be eaten, while on Feb. 15, after starvation for twenty-four hours, many Acræas were swallowed whole. The behaviour on this occasion renders it certain that, as in the case of *Bucorax caffer*, *L. chrysippus* was far more distasteful to the kestrel than the Acræas.

The rejection, after trial, of the evil-smelling Coreid bug *A. curvipes*, greedily eaten by baboons, is a good example of the difference in value of the same defence with different enemies.

The treatment of Coleoptera almost invariably supported the theories which explain the meaning of insect colouring as cryptic, warning, etc.

The following beetles were eaten by the kestrel: *Curculionidæ*, with cryptic colouring (*Oosomus*, sp., and *Eremnus*, spp.); the large, slow-moving, conspicuous, black, earthy Heteromeron *Anomalipus plebeius*, when the chitin was broken; the smallish Buprestid *Amblysterna vittipennis* (dark metallic green or coppery with white stripe on each elytron); the Heteromeron *Dichtha inflata*, dark brown with reddish stripes, conspicuous and slow-moving like *Anomalipus*; the medium-sized Scarabeid *Onitis alexis* with elytra and legs brown, and thorax iridescent green.

It is probable that most of the defensive fluid had been already discharged in the case of the *Carabidæ* of the genera *Piezia*, *Polyhirma*, and *Graphipterus*, of which the acid secretion was seen to be a very positive protection when there was opportunity for its operation on a normal scale. The Longicorn *Ceroplesis fallax* with a Cantharid type of colouring may be synaposematic, as it was only eaten very slowly although the bird had been kept without food. The impression produced by the stridulation is of much interest (see p. 403).

The following beetles were refused, usually after tasting :—

Cantharidæ :—*Mylabris palliata*, *M. holosericea*, *Eletica rufa*, *Zonitis* sp. (all most conspicuous).

Coccinellidæ :—*Epilachna dregei* (characteristic colouring).

Cleridæ :—"*Clerus*" sp. (scarlet).

Phytophaga :—*Diacantha conifera* (Lycoid).

Melyridæ :—*Prionocerus dimidiatus* (Lycoid).

Lycidæ :—Three characteristically coloured species of *Lycus*.

Cetoniidæ :—*Clinteria infuscata* (orange thorax with two black spots, brown elytra, sometimes black).

Heteromera :—*Lagria*, sp. Probably distasteful, conspicuous and synaposematic with Phytophaga.

Scarabæidæ :—*Onthophagus gazella*, smallish Scarabæid with brown elytra and iridescent dark green thorax and head.

With the possible exception of the last named, all these species possess distinct aposematic colouring, and nearly all belong to groups which are much mimicked, or fall into important synaposematic combinations.

Mr. Marshall specially points out that the Kestrel, *C. naumanni*, was young, and it is probable that it had never before had experience of many of these species.—E. B. P.]

10. Experiments on a tame Ground Horn-bill (*Bucorax caffer*). (G. A. K. M.)

Malvern, Natal, May 14, 1897.

March 14. Gave a tame ground horn-bill (*Bucorax caffer*), belonging to Col. J. H. Bowker, the following butterflies : two male *A. serena*, one *P. lyæus*, one male *H. misippus*, one male *A. serena*, all of which he ate readily, taking them in the end of his beak, crushing the thorax and throwing them down his throat. I then gave him *L. chrysippus*. He took it, crushed the thorax and dropped it at once. A second specimen given a short time afterwards was treated in the same manner.

„ 24. Gave the following butterflies to ground horn-bill : three *A. encedon*, one *A. petræa*,